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The same exposure may give all the result of an under-timed picture with one developer, and of an over-timed negative with another. An experiment of last winter will make my meaning clear. With a six-inch objective, 92-inch focus, I made four exposures on the crescent moon. All the plates used were Seed's 26; time one-fourth of a second. In developing plate no. I, I used a cold pyrogallic solution. Result—an under-timed plate; no details. The second plate was developed with a normal solution of Hydroquinone. Result,—more details, but still under-timed. Plate no. III, was brought out by Eikonogen. Result,—perfect details, appearance of a well-timed negative. For Plate no. IV, I used the same Pyrogallic developer used on Plate no. I, only it was heated to 130 degrees. Result, an over-exposed negative which had to be retarded with K Br. This proved to be the best negative, on account of the richness of its details. I should add, however, that all brands of plates will not stand this high temperature. In winter, Seed's and Cramer's plates will give beautiful results, with this warm treatment, especially for instantaneous work. The gelatine film becomes very soft, hence great care is required in all subsequent washings.

By way of recapitulation, I may recommend the following, in order to obtain greater extension of coronal streamers.

I—To use Orthochromatic plates. I consider Vogel's Eoside of silver the best, when fresh, or Seed's 26, when developed with a warm pyro developer in winter.

II—The greatest precaution to guard from all foreign light.

III—Short exposures to obtain the polar filaments and the inner corona.

IV—Long exposures to secure the extension of the outer corona.

V—Photographing each wing separately, and keeping the brighter part of the eclipse out of the field.

ST. CHARLES, MISSOURI, October, 1890.

THE KENWOOD PHYSICAL OBSERVATORY.

BY GEORGE E. HALE.

At the request of Prof. HOLDEN, I am glad to write the following account of our new observatory in Chicago. The special nature of the work for which it is designed may give this paper an interest it would not otherwise possess.

In the summer of 1888 we erected a small brick building for spectroscopic purposes on the corner of Drexel Boulevard and 46th Street. It contains a general laboratory, "slit-room," "grating-room," and photographic dark-room. With the exception of the laboratory, the walls and ceilings of all the rooms are painted dead black, and light-tight shutters and curtains on the few windows assure almost perfect darkness. A concave grating, mounted as described by Prof. ROWLAND, is the principal instrument. The grating-room contains three brick piers situated at the vertices of a right triangle, the right angle being at the north-east corner of the room. Two heavy wooden beams are supported on the piers, and form the sides about the right angle. To each beam an adjustable steel rail is bolted, and these would meet, if produced, at the apex of the right angle. At this point the slit is placed. It is very accurately made, with jaws of glass-hardened steel, and is capable of rotation about a horizontal axis, by means of a tangent screw, in order to set it exactly parallel with the lines of the grating. The partition between the slit room and grating-room is so built that it comes directly behind the slit, the light entering the grating-room through a short tube passing through the partition and screwed to the back of the slit-plate. Thus the slit is entirely without the grating-room, and any light-source can be used before it without the least danger of fogging the photographic plate on which the spectrum is received. A carriage moving on the north and south rail carries the grating, and is connected with a carriage on the east and west rail by a girder about ten feet long. On the latter carriage is held an eye-piece for observing the spectrum, or a plate for photographing it. The concave grating was ruled by Prof. ROWLAND. The ruled surface is $3\frac{5}{8}$ inches long and $1\frac{3}{8}$ inches wide, and has a radius of curvature of about 10 feet. It contains 14,438 lines to the inch, thus making available the whole of the first two orders of spectra, and a portion of the third and fourth. For work on very faint light-sources, such as the electric discharge in rarefied gases, a second grating of only 5 feet radius is used, of course with a short girder. This grating gives almost all of its light in one of the first spectra, and is exceptionally useful for the purpose mentioned. The grating-holder can be rotated about either one of three axes, and, when in use, the face of the grating is at right angles to the girder. With the long focus grating, photographic plates 10 inches long can be used, by bending them to a curvature of about 5 feet. Different regions of any spectrum are brought on to the plate by moving the carriage

along the track. The focus is the same at all points, and the photographed spectrum is normal.

A building near by contains the dynamo from which electric currents are obtained. It is a 70-volt WESTON machine, and is driven by a gas-engine of 6-horse-power. A set of 35 JULIEN storage cells can also be used when desired. The current is led into the slit-room to a specially constructed arc lamp or a large induction coil, suitable resistance being interposed in each case. The image of the arc or spark is thrown on the slit by a quartz lens, and the spectra are readily photographed edge to edge with the solar spectrum. Sunlight is thrown on the slit by a heliostat, placed on a pier far enough to the north of the building to be out of the shadow. Suitable absorbing solutions before the slit serve to cut out the overlapping spectra.

When photographic enlargements of spectra are required, they are made in the slit-room by the aid of camera lenses. A GEISSLER pump is employed with various forms of vacuum tubes for the study of gaseous spectra. In such cases the required exposure is much reduced by using the short focus grating. The rooms are so connected by double doors that it is possible to pass through them all without disturbing any plates which may happen to be exposed. They are lighted by incandescent lamps when necessary.

A considerable amount of experimental work was carried on in this building during the summer months of 1888 and 1889. The capacity of the apparatus was fully tested by a long study of the solar spectrum, notably in the region of H and K. The arc spectra of many metals were also photographed, and the reversals investigated. But my absence from the city during a large portion of each year, made it impossible to conduct any continued research, and the apparatus has always been dismounted in the winter.

In the summer of 1889 Mr. BRASHEAR built for me a large telespectroscope, which was used last winter in solar work at the Harvard College Observatory. This instrument has already been described, as well as the research conducted with it. (*Technology Quarterly*, No. 4, 1890.) A frame of strongly braced steel tubing carries the two telescopes, which make with each other a constant angle of 25° . The objectives are exactly alike, about $3\frac{1}{4}$ inches clear aperture and $42\frac{1}{2}$ inches focus, and are made of Jena glass. The grating is of the same size as the large concave grating described above, but is, of course, plane instead of concave. The jaws of the slit move equally in both directions from the center, and the whole

slit-plate can be moved across the end of the collimator by a screw. A large 30° prism is now being made for faint stellar spectra. The whole instrument is a model of excellent workmanship, and optically it leaves nothing to be desired.

The work at Cambridge was to test a new method of photographing the solar prominences devised by the writer in 1889. But a horizontal telescope was used, and the distortion of the mirror by the sun's heat made it impossible to secure photographs of any value. It seemed very desirable to continue the work with an equatorial, and a few months ago it was decided to considerably enlarge our old building, and add a 12-inch refractor in a dome $26\frac{1}{2}$ feet in diameter. To this instrument the spectroscope will be adapted. Mr. J. A. BRASHEAR, who has so skillfully constructed all of our more important optical apparatus, is now at work on the new object-glass. It is to have the rather long focus of 18 feet, as this is allowed by the size of the dome. Messrs. WARNER & SWASEY are to supply the dome and mounting. The latter is made extra heavy; in fact, it is of the size ordinarily used for a 15-inch glass. The spectroscope and tube are to be mounted as if in one piece, the declination axis coming at the center of their combined lengths. This will give great rigidity, and render necessary very little weighting at the object-glass. The tower for the dome is two stories high, and has stairs leading directly to the dark-room for convenience in photographic work. The lower room of the tower is to be fitted up as a workshop with a lathe and a good assortment of tools. It is intended in the future to derive power from an electric motor, and drive a drill press, shaper, engine lathe, etc. The equatorial pier is very substantially built on broad concrete foundations, and encloses a sidereal clock. As the observatory is designed solely for spectroscopic investigations it will contain no meridian circle of transit instrument, except, perhaps, a small transit for time observations. A room is to be provided with cases for a library, and our special subjects are already well represented by a good number of volumes. All pamphlets and books are made easy of reference by a complete card catalogue, and this is found to be a great convenience in the case of pamphlets, even in so small a collection.

As soon as the equatorial is in place the work of photographing the prominences will be recommenced, and this will be the special research of the winter. A study of various organic dyes is now in progress, as plates very sensitive to the region of the spectrum near the solar line C are desired for the prominence experiments. The

large concave grating is also being used in an investigation of arc and spark spectra, in comparison with the solar spectrum.

If any members of the A. S. P. happen to be in Chicago, I shall be pleased to welcome them to our observatory if they care to visit it.

CHICAGO, November 4, 1890.

THE LAW OF THE SOLAR CORONA.

PROFESSOR FRANK H. BIGELOW.*

In compliance with a request from Professor HOLDEN, I send a brief summary of results of some studies on the Solar Corona, referring the Society to the paper published in the *Amer. Journ. Sci.*, Nov., 1890, for the mathematical details. This computation refers to the La Junta photograph of July 29, 1878, but similar calculations are sufficiently advanced on the coronas of 1889 to state that they all seem to conform to the same analysis, and that the same equation is applicable to each.

The Newtonian law of the potential in its inverse action, when applied to a polarized sphere, is laid at the basis of the work, and as its proof by several methods is given in connection with its use in electricity and magnetism, we are now concerned only in the identification of the direction of the coronal streamers with the lines of force produced under these conditions. The repulsion of the surfaces of infinitesimally small particles, obeying this law, is all that is required as a fundamental conception, by way of a physical interpretation of the facts themselves.

The formula must also take account of the distortion of the rays which spring up from the sun at any part of its surface, so far as may be assumed, but are seen from the earth as if projected on the plane through the centre of the sun, perpendicular to the line of sight. Also the coronal poles may not be taken as coinciding with any line of the above plane of the disk, but we do see the plane in which they lie perpendicular to the disk, and must compute the angular distance from the disk to the coronal pole. The poles of the sun's axis of rotation, of the plane of the Ecliptic, and the plane of the equator at the centre of the sun being given, we may, from their projections on the disk, find the heliographic longitude and latitude of the coronal poles at the time of the eclipse.

*Nautical Almanac Office, Washington, D. C.